June 2011

FIRE EXTINGUISHER IQP

Chrystian Danyele Dennis
Worcester Polytechnic Institute

Scott Edward Brady
Worcester Polytechnic Institute

BullEx Inc.

Fire Extinguisher Effectiveness

IQP Report

Students: Scott Brady, Chrystian Dennis

Advisors: Kathy Notarianni

Worcester Polytechnic Institute

Table of Contents

Introduction

It is unknown today whether or not an average, untrained human possesses the skill and knowledge necessary to use a standard fire extinguisher effectively. It is known today that fire extinguishers are full of costs. Here at WPI, there was a new dormitory that was finished in 2008. This cost-friendly upperclassmen living building was made with only a quick response sprinkler system to deal with fires. Due to a change in the fire coding regarding fire extinguishers allowed this building to neglect the need of hand held fire extinguishing devices. Along with the cost off fire extinguishers comes a fear of the human ability to effectively use the device in the time of a fire. Vandalism is also a key issue when incorporating hand held extinguishers in new buildings. When buildings have fire extinguishers, the owners of the building need to make sure training is giving to all people who may use them. Therefore our experiment will demonstrate the human ability to put out a fire effectively without putting themselves at risk.

Background

BullEx

BullEx, Inc. is innovative technology company that was formed by engineers with experience in occupational safety and the fire service. These engineers devoted to utilizing smart technology to

develop life-saving products. There are three main segments within the company which include Fire Extinguisher Training Tools, Smoke Generators, and Advanced Fire Training Props.

One of their important developments was the advanced fire extinguisher training systems. This system was created due to the hundreds of training sessions that were being conducted in dangerous and non-eco friendly manner. Most training sessions exposed personnel to a dangerous fuel mixture that later raised complaints of dry-chemical coating of cars and clothes, and the cleaning up of parking lots. BullEx worked with many safety officials and fire service leaders to develop a simulator that could sense where the trainee aims and sweeps.

Intelligent Training System

This system provides clean, safe and cost effective extinguisher training. The Intelligent Training System (I.T.S.) senses where the trainee aims and sweeps the SmartExtinguisher and varies the flames automatically. The SmartExtinguishers are easily recharged by compressing air and water before each use. On the board of the system there are four sensors that determines exactly where the user is aiming and sweeping. This allows the system to have a realistic affect due to its ability to rekindle and extinguish depending on the factors. The variable electronic valves constantly adjust the amount of propane sent to the burners to simulate the fire's response to the extinguisher. The system itself has the ability to be programmed to a select class A, B or C fires at four different difficulty levels. There is an emergency- stop switch on the handheld controller and a motion sensor that shuts down the flames immediately if the system is bumped or knocked to protect the trainee.

Regulations

Current codes and standards for fire extinguishers are outlined in the National Fire Protection Association codes in chapters 1 and 10. In chapter NRPA 10 states that fire extinguishers are required to be inspected monthly (section 6.2.1) and maintained yearly by a licensed fire protection contractor (section 6.3.1). However, not all codes are required but are recommended that fire extinguishers are located along normal paths of travel, including exits from areas (6.1.3.2). As far as visual purposes a fire extinguisher shall not be obstructed nor obscured from view (6.1.3.3.1) and must have a person available for 24 hours with access to a locked fire extinguisher (A.21.3, 54).

Surprisingly in our new eco-friendly dormitory fire extinguisher are not readily available in the halls but only small handheld extinguishers are located in the kitchen of each suite. This could be due to the lack of content regarding portable fire extinguishers until the publication of the 2009 edition of the International Building Code (IBC). The IBC only referred to the International Fire Code (IFC) 906.1 which only required fire extinguishers in all occupancies except for Group R-3. However there is an exception for groups A, B, and E occupancies when quick-response sprinklers are installed throughout the building. Although this is an exception it does not eliminate portable fire extinguishers entirely.

Surprisingly in our new eco-friendly dormitory fire extinguisher are not readily available in the halls but only small handheld extinguishers are located in the kitchen of each suite. This could be due to the lack of content regarding portable fire extinguishers until the publication of the 2009 edition of the International Building Code (IBC). The IBC only referred to the International Fire Code (IFC) 906.1 which only required fire extinguishers in all occupancies except for Group R-

3. However there is an exception for groups A, B, and E occupancies when quick-response sprinklers are installed throughout the building. Although this is an exception it does not eliminate portable fire extinguishers entirely.

Our experiment is based on Class A and B fires which is defined in NFPA 10. Class A fires are fires involving ordinary combustible materials, such as wood, cloth, paper, rubber, and most plastics. This fire occurs in most building conditions and would be seen by most subjects. Class B fires involve flammable and combustible liquids, petroleum-based materials, paints, solvents, alcohols, and flammable gasses. This fire likely occurs where such items and materials are used, dispensed, or stored

The main outcome of this research is to increase training from once a year to more often while increasing the amount of people obtaining hands on experience. In order to do so this project would need to prove that a subject can be exposed to a fire and have a decent amount of knowledge and confidence to successfully minimize their danger in a fire. This experiment is not to prove if a subject can extinguish a fire completely but to see if they could remove themselves to safety without ham. This information should also prove that with knowledge and practice extinguishing fires is directly proportional to successful use of fire extinguishers and minimizing injuries with their use.

In the world of fire safety and regulations, fire extinguishers are not highly thought of in terms of their use and purpose in new buildings. This is due to the fear that human are incapable of using a device without proper training and is thought to only be used by trained personnel. Standards and codes all express interest in either training or no extinguishers at all. In fact companies would rather tell employees to drop everything and remove themselves from danger.

However in reality human instinct is to either protect their surroundings and personal belongings. This is why extinguishers would be an asset instead of a hindrance to subjects because of normal instinct to a real fire. This study should show that without experience of extinguishing a fire that humans are capable of extinguishing.

Research Methods

The first step of our research is to test the Bullex system using Class A fires, which are fires that are commonly found in households. The first step will be to put out a fire using the Bullex system. While the Bullex fire is being put out, all of the subject's motions will be recorded. By mimicking the recorded motions on a real fire with a real extinguisher, we will be able to draw conclusions about the accuracy of the Bullex system.

The second part of the project will involve the testing of the human ability to use the extinguisher. We will have multiple days of testing set up in the fire protection lab. One hundred people will be tested. The hundred people will be made up of seventy students and thirty faculty members. To ensure that the data we record is legitimate, we will follow this protocol during every test day.

The protocol starts with preparing the lab and the Bullex system for testing. Setting up the Bullex system requires a fully charged battery booster pack, a water source, a propane tank, an extension cord, along with all the essentials to the Bullex system. The Bullex system's top is filled with water up to the over flow holes. The larger Bullex extinguisher is filled with six liters of water and pressurized fully according to the gauge. The smaller Bullex extinguisher is filled with four liters, and is pressurized fully as well. The propane hose is attached to the propane tank

and the booster pack is plugged into the Bullex system. A safety line is placed eight feet back from the Bullex system. The air duct is turned on to low. The controller is finally plugged in and placed behind the safety line.

Before we have our test subjects we need to make sure that the proctor's duties are laid out. One of us will be required to start the fire while the start a stopwatch. The stopwatch will record the time it takes for the subject to see a fire and spray the agent at the system. The Bullex system records the total extinguishment time on the controller. The other one of us will be required to take observations while the subject is performing. They will be recording observations regarding turning back to the fire, reading the label, distance from fire, aiming at base, sweeping motion, rekindle, continuous spraying after fire seemed out, and finally whether or not the fire was extinguished.

After this subject has completed the first part or our trial we will ask him to read over the training script. This script briefs the subject on the labels instructions and prepares him for his second run. After the subject has had an opportunity to see how proper extinguishment is to be done, he or she will be asked to enter the test area again.

The lab is double checked for safety, and the fire is ignited for a second time. The duties for the trial are the same for the previous run. The observations and times recorded in the first run are repeated. After the fire is put out, the subject will be asked to fill out a brief survey to complete the testing.

Results

The Bullex system was used to test 64 student's abilities to extinguish the Bullex fire effectively. After the initial trail, all 64 subjects were briefed on how to effectively use the extinguisher and asked to perform the test again. Our test subjects were comprised of 13 female subjects and 51 male subjects. The average age of our test subject was about 19.5 years old. The ages ranged from 18 years old to 23 years old.

There were many specific data points we wanted to look at regarding proper extinguishment technique. These points of interest included turning back to fire, reading the label, distance from fire, sweeping motions, aiming at base, and continuing to spray to prevent rekindling. There was only one test case where a subject turned their back to the fire. It was very interesting to see that only 48% of our test subjects read the label during their first test run. Only one tester proceeded to read the label before she sprayed for a second time. Out of the 64 subjects, only 17% of them failed to use any sweeping motions at all. Out of the 17% of the subjects who didn't use the correct sweeping motion, 100% of them showed the proper sweeping technique in the second trial. Although, a few test subjects seemed to be sweeping too abruptly. During the first trial, 37.5% of the subjects failed to aim at the base of the fire. Since we explained the proper technique before the second trial started, we were able to see improvement in every subject but one. Since the Bullex system is very accurate at mimicking a real fire, the system seemed to rekindle if subject stop spraying too quickly. Like the previous data we found, we saw great improvement from the first round to the second round. We saw the fire rekindle 53% of the time in the first round, and only 17% in the second round. This is probably due to the fact that only 40% of the subjects continued to spray before being seeing how the system could mimic rekindling. The second round showed 80% of subjects spraying until the round ended.

We wanted to accompany our technique observations with specific time observations. Our experiment was set up to record the time it took to start spraying agent. The Bullex controller records the time from ignition to when the fire is put out. With these two times, we were able to find out how long our subjects took to start spraying and put out the fire. To start spraying the extinguisher, our subjects had to walk over and pull the safety pin out. This required a breaking of the plastic strap holding the pin in and sometime reading the label. The subjects then had to walk up to the safety line and squeeze the triggering device of the extinguisher while pointing the nozzle at the fire accordingly. The average time accomplish all of these tasks was 10.8 seconds, while the median time was 7.8 seconds. There was a large range of time because almost half our subject read the label the first time spraying. One subject took over 48 seconds to spray while another subject proceeded to spray in only 2.7 seconds. The average time of the whole test cycle was 16.7 seconds while the median was 15.2. The longest time was 56.3 seconds while the fastest time was just 5.2 seconds! It was very interesting to see that the average extinguishment time was just 5.9 seconds. One fire was put out in 1.7 seconds while one subject took over 16 seconds. It was impressive to see that 77% of the subject had a faster extinguishment time after being trained. The median extinguishment time came in at 6.35 seconds.

We needed to figure out the percentage of students who were able to use all the proper techniques to extinguish fire in a reasonable amount of time. It seems that about 41% of the students were able to extinguish the fire effectively during their first trial. The second trial had double the amount of students using proper technique. 79% of students aimed at the base, used a slow sweeping motion, continued to spray, and actually extinguished the fire in a timely manner

in the second trial. The fire system's rekindling tendency seemed to surprises the student who had little experience with fire safety.

We had all the students fill out surveys after their second test. These surveys showed that the test subjects more often than not had "a little" or "some" knowledge of how a fire extinguisher works. It seemed that over half our subjects have witnessed a live fire emergency. It is also clear that many of our subjects don't even remember their last fire training course, although most students can recall their last fire drill. It seemed the students gained confidence with the extinguisher, and knowledge on how to use it effectively. Most students were able to list the important aspects of the fire extinguisher technique, along with some key things to avoid. The survey decisively showed that the students all believed that fire extinguishers are a necessity and useful.

Conclusion

There is so much that we can pull from the data we have found during our time testing in the fire protection lab. Our experiment was set up to observe students with little or no training in the first trial. With only the label on the extinguisher for directions, 40% of our test subjects were able to eliminate the fire with proper technique. Almost half of our test population was able to use what little prior knowledge they had in addition to their common sense to demonstrate a very specific extinguishing technique. Obviously, students will be trained and briefed according to the fire codes if they would actually be using the extinguishers provided in our school. As mentioned in our results section, 80% of our test subjects were able to prove competence in extinguisher technique. This massive increase in the percentage of students who could demonstrate this

technique came after only a brief explanation of the key techniques used in proper extinguishment. So clearly, the students here at WPI can be trained appropriately.

It is known today the extinguishers can be costly and even dangerous, not to mention the tendency for extinguisher to be involved with vandalism. These are some main reasons why buildings such as East Hall at WPI are being built with neglect to extinguishers importance. If we have shown that over 80% of students can be trained very simply in a 5 minute training session, should this lack of extinguishers in the corridors of East Hall be reconsidered? Should buildings really be neglecting extinguishers because they are too expensive to be maintained and too difficult to provide the proper training?

We feel that our data showed that a typical WPI student is capable of being trained to use this life saving fire safety tool correctly. It is clear that lives are put into danger when students are allowed to put themselves in front of a fire. Although, it is also clear that damage control would be greatly increased if we could avoid the damages of the sprinkler system by responding to the fire quickly with an extinguisher.

The fire coding regarding extinguishers clearly have put the life-saving hand held device second to sprinklers systems. After analyzing our data, we feel that this is not warranted to fail to incorporate extinguishers in to the fire safety plan. We know that certain risks follow the extinguishers, but we are also certain that risks follow the lack of extinguishers too. We feel that people deserve the opportunity to have the hand held safety device with them in times of emergency especially now that it is proven that students are capable. There are great advances in the ways extinguishers are maintained and protected so vandalism is reduced and functionality is ensured in times of emergencies. An extinguisher can stop a fire before it spreads, help a group

of students work their way to an exit, break a window if need be, prevent water damages from sprinklers, and of course they can save the lives of WPI's students and faculty.